Analysis of Issues and Options

for the

First National Communications of

OPEC Member Countries

Draft report prepared by TERI, New Delhi

For the OPEC Secretariat, Vienna

9 November 2000

Table of Contents

1. Background

In the last two decades, climate change has emerged as an environmental and developmental issue of global concern. Recognizing that the global nature of climate change calls for a cooperative and coordinated response by all countries, the Framework Convention on Climate Change (FCCC) was negotiated and entered into force on 21 March 1994. The ultimate objective of the FCCC is the stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The FCCC also calls for all Parties to commit themselves to:

- Develop, update periodically, publish, and make available to the Conference of Parties to the FCCC, their national inventories of anthropogenic emissions by sources and removal by sinks, of all GHGs not controlled by the Montreal Protocol.
- Use comparable methodologies for inventories of GHG emissions and removals to be agreed upon by the Conference of Parties.

In accordance with Article 12.1 of the FCCC, the initial national communication of non-Annex I Parties should also include a general description of steps taken or envisaged by the Party to implement the FCCC, along with any other information considered relevant to the achievement of the objective of the Convention, including material relevant for calculation of global emission trends. Parties may also present information on their specific needs and concerns arising from the impact of the implementation of response measures. In this regard, Decision 10/CP.2 specifically mentions countries whose economies are highly dependent on income generated from the production, processing, and export, and/or on consumption of fossil fuels and associated energy-intensive products; and other special considerations foreseen in Article 4.9 (referring to least developed countries) and Article 4.10 (referring to fossil-fuel dependency). The Organisation of Petroleum Exporting Countries (OPEC) comprises economies that are substantially dependent on exports of oil and other related products should use this opportunity to represent their concerns.

OPEC countries are required under Articles 4 and 12 of the FCCC to submit their National Communications, including national GHG inventories. The purpose of this report is to address and analyse key issues that are relevant for OPEC member countries in order to assist them in the preparation of their National Communications. These issues have been identified as:

1. Reportage of non-mandatory GHGs
2. Choice of emission factors
3. Gas venting and flaring
4. Level of emissions

This report first presents an overview of GHG emissions from OPEC countries, along with an analysis of the growth in emissions from each OPEC country, and the sources of these emissions. The next section identifies the relevance to OPEC of issues related to the preparation of national GHG inventories. Subsequent sections focus in detail on the four key issues listed above, analyse the implications for OPEC countries, and provide recommendations. In doing so, the report will review the approach taken by Annex I as well as non-Annex I countries, and take into consideration the particular needs and circumstances of OPEC member countries.

2. Overview of OPEC emissions

The 11 OPEC countries together produce about 40% of the world's oil and hold more than 70% of the world's proven oil reserves. Saudi Arabia and Kuwait are the two largest producers of oil. Further, Arab states account for more than a third of the world's proven reserves of natural gas. OPEC's share of world oil supply remained constant at about 39.5% between 1993 and 1996. However, OPEC oil production increased by about 1.6 million barrels per day in 1997, and by another 0.5 million barrels per day in 1998, out of a total global oil supply growth nearly 3.2 million barrels per day between 1996-98, thus increasing its share of world oil supply by more than 1% (EIA 2000) to 40.5%.

The International Energy Agency has estimated CO_2 emissions from fuel combustion over the period 1971-1997 (IEA 1999). These emission estimates are based on IEA energy databases, and the default methods (reference approach) and emission factors suggested by the IPCC Revised 1996 Guidelines (IPCC 1997). The IEA estimates for emissions from fuel combustion include fugitive emissions from fuel transformation. Table 1 presents the IEA's estimates of CO_2 emissions for OPEC countries. Table 2 describes the CO_2 intensity of primary energy supply, which is given by

$$CO_2 \text{ intensity} = \frac{CO_2 \text{ emissions from fuel combustion}}{\text{Total primary energy supply}}$$

Table 1. Total CO_2 emissions from fuel combustion (million tonnes CO_2)

	1990	1997	% change 1990-97
Algeria	59	65	8.9
Indonesia	155	257	65.3
Iran	200	285	42.3
Iraq	58	77	33.7
Kuwait	34	45	32.2
Libya	30	38	29.7
Nigeria	39	54	37.1
Qatar	13	32	136.3
Saudi Arabia	169	266	57.9
UAE	55	78	40.0
Venezuela	94	137	44.9
OPEC total	908	1333	46.9
World	21246	22981	8.2
OECD total	11176	12235	9.5
Non-OECD total	9694	10326	6.5

Source: IEA (1999)

Table 2. CO_2 intensity of total primary energy supply (tonnes CO_2/tonnes of oil equivalent)

	1990	1997	% change 1990-97
Algeria	2.5	2.4	-1.6
Indonesia	1.6	1.9	17.8
Iran	2.8	2.6	-5.1
Iraq	2.8	2.9	2.9
Kuwait	2.6	2.8	7.3
Libya	2.5	2.5	1.2
Nigeria	0.6	0.6	10.9
Qatar	2.3	2.3	0.0
Saudi Arabia	2.7	2.7	1.5
UAE	2.6	2.5	-2.3
Venezuela	2.3	2.4	3.0
World	2.4	2.4	-2.1
OECD total	2.5	2.4	-3.2
Non-OECD total	2.4	2.2	-1.3

Source: IEA (1999)

CO_2 intensities are decreasing at the global level, but for the OPEC members, with the exception of Algeria, Iran and UAE, the carbon intensities are increasing.

Table 3 provides an assessment of the sources of CO_2 emissions from OPEC member countries. Using data available from the Carbon Dioxide Information Analysis Center, quoted in WRI (1999), it presents a breakup of CO_2 emissions from the burning of solid, liquid, and gaseous fuels, gas flaring and cement manufacturing. For OPEC member countries, solid fuels are a relatively small source of emissions, whereas emissions from gas flaring comprise an important fraction.

Table 3. CO_2 emissions from fossil fuel burning and cement manufacturing in 1995 (thousand metric tonnes CO_2)

	Percentage of emissions from					
	solid fuels	liquid fuels	gaseous fuels	gas flaring	cement manufacturing	Total emissions
World	39.7	36.7	18.4	1.0	3.0	22714561
Algeria	3.6	24.3	51.7	17.1	3.4	91267
Indonesia	12.5	64.6	17.1	2.6	3.3	296132
Iran	1.3	57.7	31.3	6.5	3.1	263760
Kuwait	0.0	60.2	35.8	2.0	2.0	48720
Libya	0.0	64.9	23.5	8.7	2.9	39403
Nigeria	0.2	32.2	9.4	56.8	1.4	90717
Qatar	0.0	12.16	60.75	23.25	1.74	19450
Saudi Arabia	0.0	58.5	30.5	7.9	3.1	254252
UAE	0.0	31.0	63.6	1.0	4.4	68304
Venezuela	0.7	46.2	44.4	6.8	1.9	180243
Iraq	0.0	84.7	6.1	0.1	9.1	99001

Source: WRI (1999)
Qatar data provided by OPEC.

The OPEC countries produce a large percentage of world oil, most of which is for export. The flaring of gas associated with this production is counted as emissions from OPEC countries. Within the OPEC members, the share of emissions for gas flaring is particularly high for Nigeria, Qatar[1] and Algeria.

Besides flaring of gas, part of the gas is vented, i.e. gas is released to the atmosphere without burning. Gas vented comprises mostly methane[2], which is 21 times more potent than CO_2 as a GHG. However, data on the amount of gas vented and gas flared is not available separately.

[1] Gas flared & vented is reported as zero in Chabrelie (1997).
[2] The composition of natural gas varies from field to field.

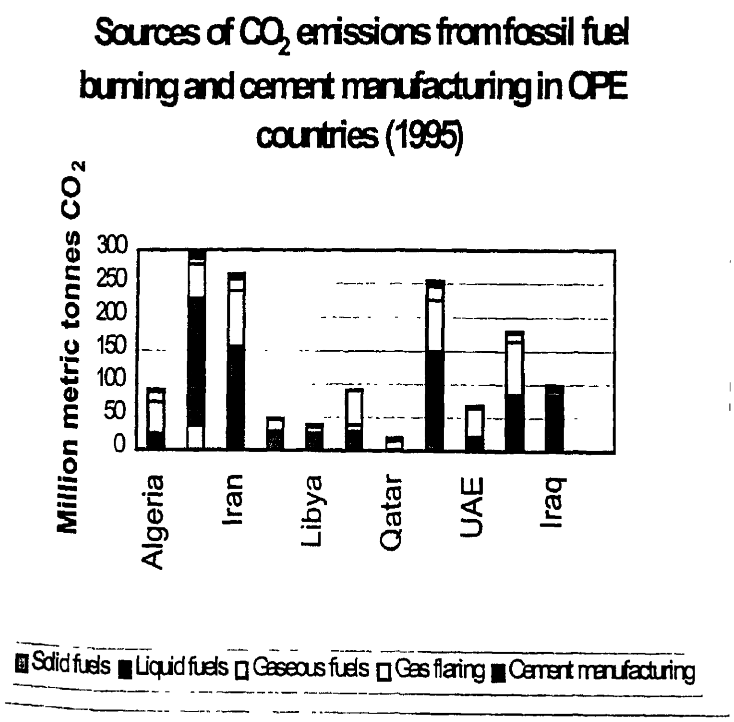


Fig 1. Share of different fuels in OPEC CO_2 emissions

3. Issues related to national GHG inventories

The construction of national GHG inventories allows the identification of activities that are major contributors to GHG emissions. This provides the basis for implementing cost-effective measures to limit GHG emissions. and enables countries to negotiate future emission targets based on existing or baseline data.

To monitor emissions of GHGs, it is essential that national GHG inventories contain the most accurate information possible for all major GHG sources and sinks. As such, inventories must be consistent, comparable, complete, and transparent. The Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National GHG Inventories provide such a methodology for the estimation and periodic update of national GHG inventories. There are, however, several key issues related to the application of the IPCC Methodology, for instance, use of default data, methods, assumptions, etc. The choice of data, parameters, and methods would critically influence the preparation of national GHG inventories. This in turn would have significant implications for a country's future course of climate change-related action.

3.1 Relevance of inventory issues for OPEC countries

The underlying key issue concerning efforts to prevent undesired climate change effects due to increasing GHG accumulation in the atmosphere is the control on the rate of anthropogenic emissions. Regarding this issue, Article 4, paragraph 2 of the FCCC stipulates that "the developed country Parties and other Parties included in Annex I commit themselves specifically as provided for in the following: (a) each of these Parties shall adopt national policies and take corresponding measures on mitigation of climate change, by limiting its anthropogenic emissions of GHGs and protecting and enhancing its GHG sinks and reservoirs." For non-Annex I countries (i.e. developing countries) the Convention follows the principle of 'common but differentiated responsibilities'.

Presently developing countries have no commitments towards GHG mitigation under the Kyoto Protocol. However, it is perceived that certain key developing countries that have fast-growing emissions would be subject to some form of commitments in the near future.

Consequently, the national GHG inventory estimate in the first national communication of OPEC member countries acquires considerable significance. It is, therefore, important for each country preparing its national inventory to explore the available options and approaches, and to apply the IPCC Methodology in a manner most suited to its national conditions.

OPEC member countries must make the best possible effort at reporting their GHG emissions. Inventory data, methodologies, and hence, emission estimates may not be very accurate today (particularly in the case of non-CO_2 gases). An attempt should be made to report these, clearly indicating the level of uncertainty associated with the estimate. Such data will form the basis for future refinements.

Given the uncertainties, the possible flexibilities regarding emission factors and data gaps, national inventories can be constructed to present a "high emissions" case and a "low emissions" case. The pros and cons of such reporting are as follows.

Concerns have been raised that reporting high levels of emissions would position the reporting OPEC member nation as a relatively significant contributor to global GHG emissions, as a result of which, it may be subjected to emission targets. But at the same time, a higher baseline level of emissions would result in a higher level of assigned amounts or emissions allowed in the future. Reporting low levels of emissions today will imply that the reporting country is not a large emitter of GHGs and does not merit imposition of commitments to reduce emissions. With a low base figure (with low level of reporting) the rate of future growth would seem higher. Also any future targets would be more stringent due to the low baseline. Strategically, it may be desirable to report higher levels of emissions. Reporting high or low is related to other components of this

study (e.g. flaring and venting of gas, as well as the level of future emissions) and is discussed in the other sections.

4. Reportage of non-mandatory GHGs

The Kyoto Protocol requires Parties to report sources and sinks of six GHGs. These gases, which are listed in Annex A of the Kyoto Protocol, are:

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Nitrous Oxide (N_2O)
4. Hydrofluorocarbons (HFCs)
5. Perfluorocarbons (PFCs)
6. Sulphur hexafluoride (SF_6)

HFCs, PFCs, and SF_6 are compounds with high GWPs and long atmospheric lifetimes that are used as alternatives to ozone depleting substances being phased out under the Montreal Protocol. HFCs and PFCs are used in

- Refrigeration and air conditioning
- Fire extinguishers
- Aerosols
- Solvents
- Foam production
- Sterilization equipment, manufacture of adhesives, coating, and inks

The uses of SF_6 include

- Gas insulated switch gear and circuit breakers
- Fire suppression and explosion protection
- Insulating medium, leak detectors, electronic applications
- Production of aluminum and magnesium

Article 12.1 of the FCCC requires that each Party shall communicate to the Conference of Parties (COP), through the Secretariat, inter alia, a national inventory of sources and removals by sinks of all GHGs not controlled by the Montreal Protocol. Parties should report emissions and removals of any other GHGs whose 100-year Global Warming

Potential values have been identified by the IPCC and adopted by the COP. It also require that the parties should also provide information on indirect GHGs, such as carbon monoxide, nitrogen oxides, and non-methane volatile organic compounds, and are encouraged to provide information on suplhur oxides.

Decision 10/CP.2 of the COP provides guidelines, facilitation and process for consideration for communications from non-Annex I Parties to the FCCC. In the case of non-Annex Parties, reporting emissions of CO_2, CH_4 and N_2O is deemed mandatory. In the case of the fully fluorinated compounds, i.e. HFCs, PFCs, and SF_6, reporting is optional. But Parties are encouraged to include these gases in their national inventories as appropriate. Other GHGs included in the IPCC methodology may be included at the discretion of the reporting Party. However, non-Annex Parties who wish to voluntarily submit additional information may use elements from the guidelines approved for Annex I Parties when preparing their initial communications.

The level of reliability of GHG emission estimates is different for CO_2 and the other gases. The former can be reported with greater precision as the emission estimates depend mainly on the carbon content of the fuel, the amount of fuel used, and the fraction of carbon oxidised. However, emission estimates of non-CO_2 GHGs are less reliable as they depend on the type of fuel, technology used, size and age of equipment, operation temperature, combustion efficiency, maintenance and operating conditions, etc.

OPEC countries can report any human-induced emissions and removals in their inventory as long as they can be clearly documented and quantified. Of the 11 OPEC countries, Indonesia and Venezuela have already prepared their first national communication. In addition to reporting CO_2, CH_4, and N_2O, Indonesia has also reported emissions of carbon monoxide (CO) and nitrous oxides (NO_x); whereas Venezuela has also reported emissions of CO and non methane volatile organic compounds (NMVOCs). Even in the case of Annex I countries reporting their 1995 emissions, on average only half estimated emissions of HFCs, PFCs, and SF_6.

- Important considerations in deciding whether to report non-mandatory GHGs would be the **availability and reliability of data, and the ease of monitoring and measurement**.
- For individual countries, the **importance of sectors emitting HFCs, PFCs, and SF_6 in the economy** would be a significant deciding factor.
- From a longer-term perspective there are potential benefits of reporting all GHGs as well. Although currently, developing countries are required to only report CO_2, CH_4, and N_2O emissions, it is likely that in the future reporting will extend to cover other GHGs as well. It is in the interest of OPEC nations to develop a database and measuring and reporting capacity at the earliest.

Hence, if OPEC countries start reporting emissions of other than the mandatory GHGs now, this could constitute an important **capacity-building** effort. At a later stage, experience in measuring, monitoring, and reporting emissions of HFCs, PFCs, and SF_6 would prove to be a valuable advantage relative to other non-Annex I countries.

Thus it is recommended that:

- OPEC countries estimate emissions of all GHGs to the extent that it is possible to do so.
- Reporting of all mandatory GHGs should be accompanied by explanation on the level of associated uncertainty. If the level of uncertainty is very high, then that GHG should not be included in the National Communication.
- OPEC countries should develop the capacity to report all gases, or else clearly state their limitations in being unable to do so.
- The level of uncertainty in the estimates of non-mandatory GHGs should be clearly stated.
- OPEC countries should ensure that their emissions are correct and accurate in all respects, to the extent possible. If the Kyoto Protocol is indicative of future commitments, then it is aggregate emissions, i.e. all six gases, which will be considered.

5. Choice of emission factors

The IPCC Guidelines were developed for a wide range of users and hence, allow a high degree of flexibility in estimating national GHG inventories. Flexibility refers to the possibility for reporting Parties to choose different methods, emission factors, and assumptions for estimating GHG inventories as allowed and encouraged by the IPCC Guidelines (FCCC 1998).

Reporting Parties may use either default methods or more advanced techniques prescribed by the IPCC Guidelines, which provide a tiered approach with increasing level of complexity. They could also use national or other compatible methodologies for estimating emissions. In addition, the IPCC Guidelines also provide default emission factors for the estimation of GHG emissions and removals. However, users are encouraged to go beyond these minimum default data and methods where possible and report the results. This default information is included primarily to provide users with a starting point from which they can develop their own national assumptions and use locally available data that is more appropriate in the specific country context.

Annex I Parties in their first and second national communications to the FCCC have used a variety of methods and emission factors in preparing their national GHG inventories, thus reflecting the different levels of disaggregation and availability of data. This information is presented in Tables 4 and 5 for the energy sector.

Table 4. Methods used by Annex I Parties for estimating GHG emissions

Energy sector source	Number of reporting Parties			
	No information provided	Tier 1	Tier 2	Tier 3
Stationary combustion	-	7	15	-
Mobile combustion	2	3	9	11
Fugitive solid fuel emissions	4	12	4	3
Fugitive oil and gas emissions	5	13	4	5

Note: Tier 1 to Tier 3 represents an increasing order of complexity in the approach.
Source: FCCC (1998)

IPCC. 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Bracknell, United Kingdom: Intergovernmental Panel on Climate Change.

WRI. 1999. World Resources 1998-99. New York: Oxford University Press.

Table 5. Types of emission factors used by Annex I Parties

Energy sector source	Number of reporting Parties			
	Default	Country-specific	Mix of default and country-specific	No information provided
Stationary combustion	9	11	5	7
Mobile combustion	10	11	4	7
Fugitive solid fuel emissions	7	7	3	7
Fugitive oil and gas emissions	9	9	2	8

Source: FCCC (1998)

The flexibility allowed in the approach recommended by the IPCC could potentially make a significant difference to a country's GHG inventory. But a review of Annex I national communications, FCCC (1998) found that the use of different methods and/or tiers does not always lead to significant differences in emission estimates. On comparison, the difference between CO_2 emissions from fuel combustion calculated using the reference (or tier 1) approach and detailed (tiers 2 and 3) methods ranged from 0.3 - 4.0%

In the case of CO_2 emissions from fuel combustion, due to relatively little variance in emission factors, and availability of total activity data from national statistics, the aggregated tier 1 approach may yield more accurate estimates than the more disaggregated tier 2 and 3 approaches. This is because the disaggregated approaches being more data-intensive, could yield more uncertain estimates if the required data are not available or are unreliable. In general, it is recommended that reporting Parties should employ both approaches, compare the resulting estimates, and attempt to explain the differences.

Table 4 indicates that for "fugitive oil and gas emissions" the first level (Tier 1) is used most frequently and there is a high level of flexibility in emission factors used. This clearly indicates the variability in data as well as the non-availability of information. From the point of view of OPEC, this is an important category as there are substantial emissions likely from oil and gas production. As before, it is recommended that OPEC reports on the higher side as this is to the future advantage of the member countries.

The use of different emission factors, however, could lead to significant differences in GHG emissions estimates in different sectors, due to potentially large differences between country-specific and IPCC default emission factors. Table 6 illustrates differences between IPCC default and country-specific emission factors in the fuel combustion sector for several Annex I countries.

Table 6. Comparison between IPCC default and country-specific emission factors for CO_2 emissions from fuel combustion (t CO_2 /TJ)

	Crude oil	Anthra cite	Coking coal	Bit coal	Sub bit coal	Lignite	Peat	Wood	Coke	Car gasoline	Aviation gasoline	Jet kerosene	Gas/ diesel oil
Austria			93-97	97	101-108				92-100	74	74	71	74
Belgium	72.6		92.7						107	69		71	73
Denmark			95					102	102	73	72	72	74
Finland			91.3				104	109		73	71	72	73.7
France	73		94.1	93	96	100		92		72.4		74	74
Germany	73			95		95	106		108	69	72	72	74
Greece			92.7			73.2-122		97.2	97.2-99.8	68.6			73
Ireland			86				104, 115			70		71	73
Sweden			91				97.1, 107.1			73	72	73	75
UK	73.3	91		90.3	99.6			104.7	106.4	67.3		68.8	69
Default IPCC 1996	73.3	98.3	94.6	94.6	96.1	101.2	106	109.6	108.2	69.3	71.9	71.5	74
Max difference(%)	0	-7.43	3	3	12	21	9	-1	0	7	3	3	1
Min difference(%)	-1	-7.43	-9	-5	0	-28	-8	-16	-15	-3	-1	-4	-6

Note: Maximum difference refers to the difference between the IPCC default and the highest country-specific value reported. Minimum difference refers to the difference between the IPCC default and the lowest country-specific value reported.

Source: FCCC (1998)

Table 7 presents the emission factors used by non-Annex I countries in preparing their energy sector GHG inventories. Most non-Annex I countries have used IPCC defaults for various fuel types. However, there were several fuels with different end-uses in developing countries for which the IPCC 1995 default emission factors were found to be inappropriate. Some examples include

- kerosene for lighting
- tars from charcoal production
- cars running on ethanol or gasohol
- biomass fuels
- black liquor from pulp and paper production
- coal with high ash and sulphur content
- hydropower plants with large reservoirs (FCCC 1999)

As oil, oil products and gas combustion, and fugitive emissions from oil and gas production are important for most OPEC countries, the subsequent discussion focuses on these sectors. The country specific variation in petroleum products is likely due to additives in the fuels affecting the fuel composition.

Table 7 : Emission factors of various fuel types used by countries for the estimation of CO_2 emissions in the energy sector ($t\ CO_2/\ TJ$)

Country	Crude oil	Natural gas liquids	Gasoline	Jet Kerosene	Other Kerosene	Gas/ Diesel oil	Residual fuel oil	LPG	Ethane	Naptha	Bitumen	Lubricants
IPCC default (d)	73.33	63.07	69.30	71.50	71.87	74.07	77.37	63.07	61.60	73.33	80.67	73.33
Bangladesh		73.33		d	d	d		d			d	d
Bolivia	d	55.73	d	d		d		d			d	d
Brazil	d	d	d	d	d	d	d	d		d	d	d
Chile	d		d	d	d	d	d	d		d		
China												
Costa Rica	d		d	d	d	d	d	d		d	d	
Cote d'Ivoire	d	63.62	71.68, 71.90	71.87	d		75.49-78.58	68.02			d	
Ecuador	d	d	d	d	d	d	d	d			d	d
Fiji			d	d	d	d	d	d			d	d
Gambia			d	71.87	d	d	d	d				
Kazakhstan			d	d	d	d	d	d				
Kiribati			d	d	d	d		d			d	d
Malawi		.	d	d	d	d						
Mexico	d	d	d		d	d	d	74.07				
Morroco	d	d	d	d		d	d			d	d	d
Nigeria		d	d	d	d	d	d			d	d	d
Pakistan	74.65	d	69.51	73.41	73.41	73.41	d			d	d	d
Peru	d		d		d	d	d	d				d
Phillipines	d		d	d	d	d	d	d	d	d	d	d
Senegal	d		d	d	d	d	d	d				
Seychelles			d	d	d	d	d	d				
Uganda			d	d	d	d	d	d				
Tanzania	d		d	d	d	d	d	d			d	d
Venezuela	d	59.40	d	d	d	d	d	d		d	d	d
Zambia	d		d	d	d	d	d	d			d	

Zimbabwe			d	d	d	d		d			d	
Max difference (%)	1.80	16.28	3.75	2.67	2.14	-0.89	1.56	17.44				
Min difference (%)	1.80	-11.63	0.30	0.51	2.14	-0.89	-2.42	7.85				

Table 7 (Continued): Emission factors of various fuel types used by countries for the estimation of CO_2 emissions in the energy sector (t CO_2/ TJ)

Country	Petroleum coke	Other oil	Anthracite	Coking coal	Other bit. coal	Sub-bit. coal	Lignite	Peat	Coke oven/ gas coke	Solid biomass	Liquid biomass	Gas biomass	Other
IPCC default (d)	100.83	73.33	98.27	94.60	94.60	96.07	101.20	105.97	108.17	109.63	73.33	112.20	
Bangladesh		d	d	d					d				
Bolivia		d	d		d		d	d	d	d			
Brazil	d	d		d	d				100.83	d	d		Tar 94.6, refinery gas56.1
Chile				d	d	d			d	d		d	City gas 98.27, blast furnance gas 242
China			96.62		88.95		88.29		88.95				
Costa Rica		d				d			d	d	d		
Cote d'Ivoire		78.58											
Ecuador													
Fiji		d			d					d			
Gambia										d			
Kazakhstan							99.37		d				
Kiribati													
Malawi						d				d			
Mexico				d						d			Solid secondary fossil fuels108.17
Morroco		d		99.77						94.60	d		Paraffin 73.33
Nigeria		d		d		d				d			
Pakistan		d		d			91.56						
Peru									d				Refinery gas 66.73
Phillipines		d				d				d			
Senegal										d			
Seychelles													
Uganda		d											
Tanzania						d				d			Animal dung 110,

													agricultural waste 110
Venezuela	101.20	d		98.27					d	d			LSG 73.33
Zambia						d							Avgas74.43
Zimbabwe				d	d				d				
Max difference(%)	0.36	7.15	-1.68	5.47	-5.97		-1.81		-6.78	-13.71			
Min difference(%)	0.36	7.15	-1.68	3.88	-5.97		-12.75		-17.76	-13.71			

The real effect of a given emission factor on the amount of national aggregated GHG emissions depends on the relative share of the emissions estimated with that emission factor. As can be seen from Table 6 and 7, the maximum variation between the IPCC default and country specific emission factor exists in the case of solid fuel emission factors (e.g. lignite and coke). An analysis of CO_2 emissions by fuel presented in Table 8 indicates that emissions from solid fuels constitute only a very small part of CO_2 emissions from OPEC countries. In most OPEC countries, the percentage of emissions from solid fuels is as low as 0-1%. In the case of the national communication of Venezuela it was reported that coal represented only 2% of energy sector emissions, due to the very low level of coal consumption in the country. The only significant exception is Indonesia, where 12% of total CO_2 emissions arise from the burning of solid fuels. Even this is very low compared to the nearly 40% share of solid fuels in total worldwide emissions from fossil fuel burning and cement manufacturing (WRI 1999).

Table 8. Carbon dioxide emissions from fossil fuel burning and cement manufacturing (1995)

	CO_2 emissions from solid fuels (thousand metric tonnes)	Total emissions (thousand metric tonnes)	Solid fuel emissions as percentage of total
World	9016712	22714561	39.7
Algeria	3243	91267	3.6
Indonesia	36893	296132	12.5
Iran	3503	263760	1.3
Kuwait	0	48720	0.0
Libya	15	39403	0.0
Nigeria	150	90717	0.2
Qatar	0	19450	0.0
Saudi Arabia	0	254252	0.0
UAE	0	68304	0.0
Venezuela	1209	180243	0.7
Iraq	0	99001	0.0

Source: WRI (1999)

Qatar data provided by OPEC.

The variations between IPCC default and country-specific factors are largest in case of solid fuels. Given the small share of solid fuels in OPEC country emissions, these are not

relevant for OPEC countries. Consequently, as far as the impact of the choice of emission factors on the inventory is concerned OPEC member countries would not be significantly impacted by using IPCC defaults if country-specific data are not available.

6. Gas venting and flaring

Fugitive emissions are intentional or unintentional releases of gases (mostly methane) during the production, processing, transmission, storage, and use of coal, oil, and natural gas. Venting and flaring refers to the disposal of gas that cannot be contained or otherwise handled. Such venting and flaring activities are associated with combined oil and gas production and take place in production areas where gas pipeline infrastructure is incomplete and natural gas is not injected into reservoirs (IPCC 1997). Venting activities release methane because the vented gas typically has a high methane content. If the excess gas is burned in flares, then the amount of methane emissions will be determined by the efficiency of the burning process.

A major problem encountered in the reporting fugitive emissions from oil and gas activities is the estimation of the total amount of vented and flared natural gas. However, most countries do not keep separate records of methane emissions due to venting, and CO_2 emissions due to flaring of natural gas at oil and gas production facilities (FCCC 1999). This is however, important for the accuracy of the national GHG inventory given the large difference in the GWP of these GHGs.

Indonesia has reported in its first national communication, methane emissions from fugitive sources, including mining or production, processing, transport or transmission and storage of fuels such as coal, oil and gas. It is reported that most of the methane emissions from fugitive sources came from natural gas production. Fugitive, methane emissions from solid fuels (in CO_2 equivalent terms) amounted to 20.40 Gg while those from oil and natural gas amounted to 2017.77 Gg.

Table 9. Carbon dioxide emissions from fossil fuel burning and cement manufacturing (1995)

	CO_2 emissions from gas flaring (thousand metric tonnes)	Total emissions (thousand metric tonnes)	Gas flaring emissions as percentage of total
World	233479	22714561	1.0
Algeria	15578	91267	17.1
Indonesia	7780	296132	2.6
Iran	17253	263760	6.5
Kuwait	986	48720	2.0
Libya	3424	39403	8.7
Nigeria	51493	90717	56.7
Qatar	4930	19450	25.4
Saudi Arabia	20005	254252	7.9
UAE	654	68304	0.9
Venezuela	12271	180243	6.8
Iraq	96	99001	0.1

Source: WRI (1999)

Qatar data provided by OPEC.

Emissions from gas flaring comprise only 1% of total worldwide CO_2 emissions from fossil fuel burning and cement manufacturing (WRI 1999). However, in the case of OPEC member countries, gas flaring and venting constitute a more significant source of emissions than the world average. Table 9 indicates that CO_2 emissions from gas flaring as a percentage of total emissions from fossil fuel burning, range from almost zero in the case of UAE and Iraq, to 56.76% in the case of Nigeria. Most OPEC countries, however, fall in the lower part of this range.

Share of gas flaring is high for the OPEC countries as a large percentage of world oil is produced by these nations. However, within the OPEC members, the share of emissions for gas flaring is particularly high for Nigeria and Algeria. Further Table 10 indicates that with the exception of Algeria and Saudi Arabia, there has been a decline in gas flared as a percentage of gross production for OPEC countries over the period 1990-1996.

Table 10. Gas flared & vented as a percentage of gross production

	1990	1996
World	4.4	4.2
Algeria	3.6	5.2
Indonesia	7.7	5.9
Iran	20.8	15.4
Kuwait	24.6	6.6
Libya	25.0	14.3
Nigeria	78.9	75.0
Qatar	0.0	0.0
Saudi Arabia	14.0	17.2
UAE		
Venezuela	8.1	7.5
Iraq	48.8	1.5

Source: Chabrelie (1997)

Question:

Is there a reason for Nigeria and Algeria having such high levels of gas flaring? This could be highlighted as a concern in the national communications.

OPEC countries should report emissions from gas venting and flaring, as they are required to under the FCCC. This will add to the baseline level of emissions reported by OPC countries, but this would also translate into a higher level of assigned amounts and less stringent targets that may be imposed in the future. OPEC countries should report as accurately as possible, emissions from gas venting and flaring, in order to identify mitigation opportunities. Estimates of gas vented as methane should be reported if possible. This again is to include all possible emissions in the baseline.

However, OPEC should also point out that there is a very wide variation between the IPCC default emission factors for different geographical regions[3] in the case of methane emissions from oil and gas activities (Table 11). This particularly applies to the category of "Other oil exporting countries" which includes the 11 OPEC countries. Moreover, this

[3] The IPCC has defined regions on the basis of key differences in oil and gas activities, limitations in data on emission factors and activity levels.

would make a substantial difference to the GHG inventory of specific OPEC countries when expressed in CO_2-equivalent terms. This would be particularly important for countries such as Algeria, Iraq, Indonesia or Iran, for which gas flaring as a percentage of gross production is close to the world average. In view of the economic importance of the oil and gas subsector, and the high GWP of methane, the OPEC countries should emphasize the need for methodological development and use of appropriate national emission factors for estimating methane and CO_2 emissions from oil and gas activities.

Table 11. Methane emission factors for venting and flaring from oil and gas production (kg/PJ)

Basis	Western Europe	USA and Canada	Former USSR, Central and Eastern Europe	Other Oil Exporting Countries (11 OPEC countries, Gabon, Ecuador, and Mexico)	Rest of the World
Oil and gas produced	-	3000-14000	-	-	-
Oil produced	1000-3000	-	-	-	-
Gas produced	-	-	6000-30000	758000-1046000	175000-209000

Source: IPCC (1997)

6.1 Role of CDM

Emissions from gas flaring are currently an inherent part of the production process in OPEC countries. Gas that is vented but not flared results in the increase of atmospheric concentrations of methane, which has a global warming potential 21 times that of CO_2. However, if the capture of gas becomes technically feasible, it may be considered as a potential mitigation option under the CDM.

The production of natural gas offers several starting points of realizing CDM projects. Natural gas is frequently associated with petroleum deposits. At the extraction stage of

petroleum, several technological options are available for dealing with the associated natural gas. These are:

a) Production and marketing of associated gas
b) Reinjecting associated gas into deposits and
c) Venting and flaring of associated natural gas.

Although the production and marketing of natural gas is the best option but it is not economically feasible as production and consumption regions are located far off. So associated gas is often vented or flared, which makes it critical from the climate change point of view. Thus, reducing the GHG emissions associated with flaring and venting of natural gas may constitute viable options for realizing CDM projects. Such projects may involve the following activities:

- Switching from venting or flaring to reinjection of the natural gas.
- Developing local markets for natural gas
- Investing in transportation systems such as long distance pipelines or LNG systems in order to supply existing but distant natural gas markets.
- Switching from venting to flaring[4]
- Utilization of natural gas as energy source for the oil production process.

In view of the potentially large emissions from gas flaring, the OPEC member country governments are already devoting their own resources to various environmental projects, including the reduction of gas flaring. It would be beneficial if these measures succeed in being backed by financial support from developed countries. One such mechanism of obtaining the necessary funding is the CDM. The purpose of the CDM as defined in Article 12 of the Kyoto Protocol is to assist developing country Parties in achieving sustainable development, and to assist developed country Parties in achieving compliance with part of their quantified emission limitation and reduction targets. In order to qualify as CDM projects, these measures have to be additional, i.e. those that would not have occurred in the absence of the certified emission reduction units (CERs)

[4] The relative environmental benefit of this option depends on the quantity of CO2 released by burning 1 cubic metre of natural gas, multiplied by the respective global warming potentials.

being generated. The proposed activities for CDM projects are not profitable under original market condition i.e. business as usual scenario. However, they may become feasible when the value of CERs is taken into account.

Alternatively, OPEC countries can undertake investment in reduction of gas flaring, and could sell the CERs to Annex I countries if a secondary market existed. Hence, OPEC countries should consider a **unilateral CDM** structure, and also the development of **secondary markets** for CERs.

A unilateral CDM structure is one where the non-Annex I country would itself develop a project, obtain the necessary financing, register it with the CDM authority, receive all or most of the certified project CERs and then bank, lease or sell them in the international market. The developing country would thus act as the main project "investor" and would retain the benefits as well as absorb the associated project risks. This system could allow a widespread and meaningful participation of the developing countries, eliminate credit-sharing negotiations and would potentially result in lower transaction costs.
However, in the current negotiations there is not much support for a unilateral CDM structure, both from annex I and non-Annex I parties. Unilateral participation by non-Annex I parties enables them to gain a share in the buyers surplus or rent. This would of course require the operation of a secondary market. Further, given the absence of primary private sector investors and the lack of resources in many host countries, the role, availability and ease of financing in the debt market will be of critical importance for this model, as will the capacity of developing countries to carry out project development and financing functions.

From a business perspective, other important issues related to the emerging international market for CERs include the timing of market entrance, banking of emission credits and possible institutional restrictions on the use of flexible instruments.

7. Future levels of emissions

This section projects future emissions from OPEC countries and compares them with the global average, and contributions from other parts of the world. This is done so as to put in perspective the share of OPEC country emissions relative to other countries.

Table 12. Growth in CO_2 emissions from fossil fuel burning

	Rate of growth of CO_2 emissions (%)	CO_2 emissions in 1995 (MtCO2)	CO_2 emissions in 2020 (MtCO2)
Algeria	2.5	58.8	109.1
Libya	2.5	41.2	76.4
Nigeria	2.5	49.7	92.1
Venezuela	3.2	112.2	246.7
Indonesia	4.0	214.7	572.3
Iran	2.5	259.4	481.0
Kuwait	2.5	44.1	81.8
Qatar	2.5	27.3	50.5
Saudi Arabia	2.5	225.0	417.1
UAE	2.5	70.7	131.0
Iraq	2.5	71.6	132.8
World	2.2	22073.4	38031.3
OECD	1.2	11725.3	15799.3
USA	1.3	5198.6	7180.0
Japan	0.9	1148.6	1437.0
Australia	0.9	283.2	354.3
EU	1.2	3178.4	4282.7

Source: IEA (1999), IEA (1998)

Table 12 presents projections of CO_2 emissions using the projected growth rates prepared by the World Energy Outlook (IEA 1998). For each OPEC country, the projected growth rate for the corresponding world region in which it is located is used[5]. As can be seen from Table 12, the projected rate of growth of CO_2 emissions from OPEC countries is expected to be higher than the world average.

[5] Algeria, Libya and Nigeria are included in Africa; Indonesia in East Asia; Venezuela in Latin America; and all other OPEC countries in Middle East.

Alternative projections of for different scenarios of economic growth are presented in Table 13. These are based on the rates of growth projected in the Energy Information Administration's International Energy Outlook 2000. Again, for each OPEC country, the projected growth rate for the corresponding world region in which it is located is used.

Table 13: Different scenarios of growth of carbon emissions; 1997-2020 (Million metric tonnes)

OPEC Countries	1997	2020					
		rog	Low	rog	Reference	rog	High
Algeria	64.7	1.4%	89.0	2.5%	114.1	3.6%	145.9
Indonesia	256.5	1.6%	369.6	2.5%	452.7	3.4%	553.5
Iran	285.3	1.5%	401.8	2.8%	538.4	4.1%	718.8
Iraq	77.3	1.5%	108.8	2.8%	145.8	4.1%	194.7
Kuwait	45.3	1.5%	63.7	2.8%	85.4	4.1%	114.0
Libya	38.3	1.4%	52.7	2.5%	67.6	3.6%	86.4
Nigeria	53.7	1.4%	73.9	2.5%	94.8	3.6%	121.2
Qatar	31.8	1.5%	44.8	2.8%	60.0	4.1%	80.1
Saudi Arabia	266.2	1.5%	374.9	2.8%	502.4	4.1%	670.8
UAE	77.7	1.5%	109.4	2.8%	146.6	4.1%	195.7
Venezuela	136.8	3.1%	276.0	4.4%	376.4	5.3%	448.6

Source: International Energy Outlook 2000

However, a more useful picture of the contributions of OPEC country emissions is provided in Figure 2 which presents the comparative per capita CO_2 emissions from OPEC countries and other world regions. With the exception of Kuwait, Qatar, and UAE, per capita emissions from OPEC countries are lower than those for the US or Australia, and in many cases even Japan. Countries like Algeria, Nigeria, Indonesia, Iran and Iraq have per capita emissions less than or comparable with the world average. This comparison is useful from the point of view of judging the necessity of future commitments. These per capita emissions have been calculated using baseline population data for 1995, while using CO_2 projections from the growth rates in the World Energy Outlook.

As CO_2 emissions from OPEC countries arise from their oil and gas production activities that contribute to GDP, an analysis is now provided of the CO_2 intensity of GDP of these countries. The baseline data for CO_2 emissions and GDP in 1995 is taken from IEA (1999). GDP is expressed in terms of US$ in purchasing power parity terms. For projections of GDP and CO_2 emissions, the corresponding rates of growth have been taken from the World Energy Outlook (IEA 1998). For each country, the projected rate of growth of GDP and projected rate of growth of CO_2 emissions for the world region in which it is located is used.

Figure 3 presents a graphical comparison of the CO_2 intensity of GDP in OPEC and other countries. For almost all OPEC countries, this indicator is higher than the world average. However, projections for 2020 reveal that CO_2 intensity is declining in almost all parts of the world, but this decline is marginal in the case of OPEC countries like Libya, Nigeria, Venezuela, etc. Hence, the high absolute levels of current CO_2 intensity of GDP and the relatively low decline in these levels is a cause for concern for OPEC countries.

In the debate on emissions targets there are three important considerations – the level of per capita emissions, per capita income level, and the GHG intensity of GDP. The latter is used as a proxy for the "efficiency" of the economy. Per capita emissions signify access and availability, while per capita incomes are taken to be representative of the ability to undertake commitments.

Table 14. Indicators for OPEC countries

	Per capita income (US$)	Per capita emissions (t CO_2 per Capita)	Intensity CO_2 (Kg CO_2 per 1990 US$ PPP)
Algeria	1600	2.1	0.71
Libya		8.3	1.71
Nigeria	260	0.45	0.38
Venezuela	3020	5.14	0.68
Indonesia	980	1.11	0.32
Iran		4.4	3.47
Kuwait	17390	27.85	1.47
Qatar		41.62	3.1
Saudi Arabia	7040	11.86	1.27
UAE	17400	30.19	2.56
Iraq		3.45	3.79
World	4880	3.92	0.72

Source: IEA (1999), WRI (1999)

From table 14, it is apparent that there would be increasing pressure on countries like Kuwait, UAE and Saudi Arabia to undertake commitments (high per capita income, high per capita emissions and high CO_2 intensity of GDP). With future commitments likely it is in the interest of the concerned party to project higher levels of emissions. This will make targets less stringent and provide a margin for economic growth.

Figure 2. Per capita CO_2 emissions in 1995 and projections for 2020

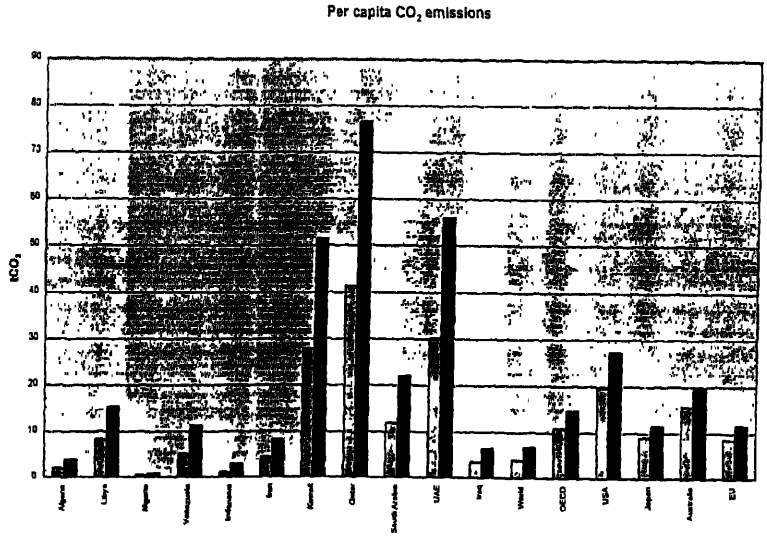
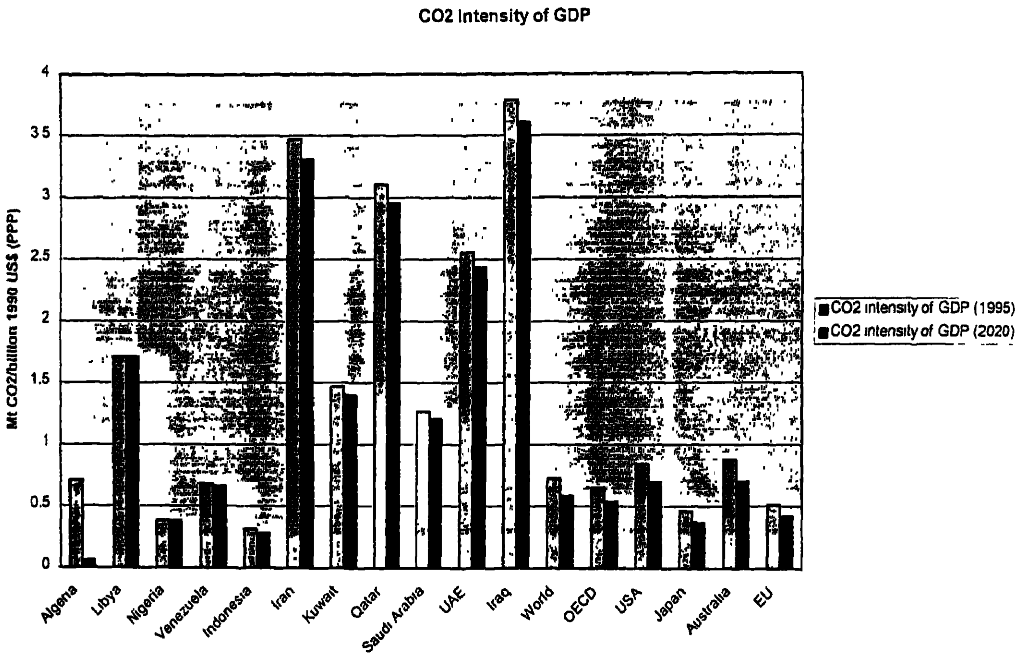


Figure 3. CO_2 intensity of GDP in 1995 and projections for 2020



8. Summary of recommendations

(To be finalised)

This report has discussed key issues related to the preparation of the first national communications of OPEC countries.

OPEC countries must make the best possible effort at reporting their GHG emissions, and should report baseline emissions as accurately as possible. It is recommended that OPEC countries report emissions of all GHGs to the extent possible, as this will constitute a significant capacity building effort. However, in reporting these emissions they should clearly state the limitations in measuring, monitoring, and reporting, and also indicate the level of uncertainty.

Using IPCC default emission factors would not significantly impact OPEC country inventories as these countries have a very low share of emissions from solid fuels, for which there is maximum variance in emission factors. The variation in emission factors is much lower for liquid or gaseous fuels, which constitute the significant source of emissions for OPEC countries. Hence, OPEC countries can use IPCC defaults, but should make efforts to develop country-specific emission factors that represent more accurately the emissions from fuels and processes used in each OPEC country.

However, country-specific analyses would be required, for instance, with respect to the composition of natural gas vented and flared. The Indonesian natural gas fields have a very high carbon dioxide content (nearly 70% carbon dioxide and 30% natural gas). The national communication of Venezuela also points out that IPCC default factors are very similar to the national factors determined by the Venezuelan Oil Research Institute, except for natural gas due to variations in its composition.

OPEC countries should report emissions from gas venting and flaring. However, they should also clearly report their limitations in doing so, and the associated level of uncertainty in the estimates reported. Reporting emissions as fully as possible would make the country a high emitter. But this would also enable the country to benefit from the CDM if it is able to reduce these emissions from its current high baseline. This would depend on the following factors:

1. Composition of gas
2. Amount of gas flared
3. Amount of gas captured / reinjected.

But given the high contribution of these processes, OPEC governments should continue their efforts to reduce these emissions. The unilateral CDM model and sales of CERs in secondary markets should be considered as a means of financing these reductions. Likely improvements in efficiency in future will assist in meeting commitments better off. A higher future baseline provides more flexibility in complying with commitments.

Finally, it should be noted that OPEC countries have high levels of per capita emissions as well as CO_2 intensity of GDP. However, OPEC countries should highlight the reasons for this, emphasising the problems and special circumstances of countries like Qatar, Kuwait, Iran, etc, including extreme climate and water scarcity.

Sources of GHG emissions from industrial processes

Process	CO_2	CH_4	N_2O	PFC	SF_6	HFC	NO_X	NMVOC	CO	SO_2
Mineral products										
Cement production	X									X
Lime production	X									X
Limestone use	X									
Soda ash production and use	X									
Asphalt roofing								X	X	
Road paving							X	X	X	X
Other	X	X					X	X	X	X
Chemical industry										
Ammonia	X						X	X	X	X
Nitric acid			X				X			
Adipic acid			X				X	X	X	
Urea			X							
Carbides	X	X						X	X	X
Caprolactum			X							
Petrochemicals		X	X			X		X		X
Metal production										
Iron, steel, and ferroalloys	X	X					X	X	X	X
Aluminum	X	X		X	X		X	X	X	X
Magnesium	X				X		X	X	X	X
Other metals	X	X			X		X	X	X	X
Other										
Pulp and paper							X	X	X	X
Food and drink production								X		
Production of halocarbons				X	X	X				
Use of halocarbons and SF6				X	X	X				
Other sources	X	X	X	X	X	X	X	X	X	X

Source: IPCC (1997)

References

Barns DW and JA Edmonds. 1990. An evaluation of the relationship between the production and use of energy and atmospheric methane emissions. TR047, US DOE/NB0088P. Washington, DC: United States Department of Energy

Decision 10/CP.2. Communications from Paries not included in Annex I to the Convention: Guidelines, facilitation, and process for consideration. 8th plenary meeting. 19 July 1996.

EIA. 2000. OPEC Fact Sheet. Energy Information Administration, United States Department of Energy. http://www.eia.doe.gov/emeu/cas/opec.html. Accessed on 6 July 2000.

FCCC. 1998. Item 4 of the provisional agenda. Subsidiary Body for Scientific and Technological Advice. Ninth session. Beunos Aires, 2-13 November 1998. FCCC/SBSTA/1998/7. 4 September 1998. http://www.unfccc.int/resource/docs/1998/sbsta/07.htm

FCCC. 1999. Comparative analysis of emission factors and activity data used for the estimation of greenhouse gas emissions in the energy and land-use change and forestry sector for some developing countries. FCCC/TP/1999/3. 24 October 1999. http://www.unfccc.de/resource/docs/tp/tp0399.htm

IEA 1998. World Energy Outlook. Paris: International Energy Agency.

IEA. 1999. CO_2 Emissions from Fuel Combustion: 1971-1997. Paris: International Energy Agency.

IPCC. 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Bracknell, United Kingdom: Intergovernmental Panel on Climate Change.

WRI. 1999. World Resources 1998-99. New York: Oxford University Press.